Guidelines for Scientific Writing

Writing is a critical element in the process of science. Good scientists also tend to be good writers, because if a scientist cannot communicate their experimental results and convince the scientific community of their study's importance, then their experiments will likely go unnoticed. Scientists communicate the results of their studies through papers published in scientific journals. Published articles are vital for their contributions to the general pool of knowledge within each scientific discipline.

There are four basic requirements of a scientific paper.

1. It must relate the scientist's study to the current pool of knowledge.
2. It must accurately and concisely describe the experimental procedures and obtained results of the study.
3. It must provide figures showing the actual data obtained (pictures, graphs, tables, etc.) so that readers can interpret the experimental findings themselves.
4. It must provide the author's interpretation of the study's results.

Parts or Sections of a scientific paper:

Title

The title of a scientific paper should be both descriptive and concise. It should say in one sentence what you did and/or found in your study. *Note, only the first letter of the first word and proper nouns within the title are capitalized.*

Examples of appropriate titles:
Parental choice selects for ornamental plumage in American coot chicks.
Influence of field margins and landscape context on ground beetle diversity in Wisconsin (USA) potato fields

Inappropriate titles:
Plumage of coot chicks
Mothers of American coot chicks feed brightly colored chicks more than experimentally manipulated dull colored chicks suggesting that ornamental plumage evolved through a process of parental selection.
Ground beetles of Wisconsin
Larger field margins and increased areas of natural vegetation surrounding agricultural fields had greater diversity of beetles compared to smaller areas

Abstract

The abstract summarizes your paper in one paragraph (limited to ~250 words). It should introduce the topic and then state the experimental methods, summarized results, and main conclusions. It is usually easiest to write the abstract after completing the rest of the paper.

Introduction

The introduction should provide the reader with general background information, summarize any current, related work that is being done by other researchers, and explain the main objective(s) or purpose(s) of your study. Most of your introduction section will come from information published in journals and texts. When scientists are reporting new findings, the introduction to their papers usually cite the work of other researchers in order to both summarize what is currently known in the field and to point out information about the topic that is still unknown or unclear. This sets the stage for the author to state the purpose of their study and why you as a reader should be interested in it.

For your formal lab writings, you will be reporting on experiments that were designed to help you gain knowledge of well understood processes in biology rather than to investigate new or poorly understood phenomena. However, you are still required to incorporate relevant information from studies reported in primary journals as well as general information from appropriate secondary sources (e.g. textbooks, published books, magazines, etc.) into your Introduction. The point of these literature citations is to emphasize how the general biology principle behind your experiment is being explored by scientists today in more depth, or alternatively, is being utilized for the advancement of medicine, industry or technology. Information from other sources is always paraphrased and a reference to the author(s) and year of publication of the source is placed at the end of the sentence (Name, year).

The Introduction should conclude by clearly stating the specific objectives, hypothesis tested ***or*** predictions based on your hypothesis. Stated objectives should be fulfilled by the experiments contained in the paper and should be very narrow in scope. Similarly, hypotheses should be statements capable of being supported or falsified by the experiment conducted.

<u>Examples of stating a paper's objective</u>:
This study investigates the relationship between solute concentration and the quantity of light the solution can absorb.

The purpose of this study is to determine the effect of temperature on the rate of DNA synthesis.

<u>Examples of stating a testable hypothesis:</u>
The experiment tested the hypothesis that higher solute concentration increases light absorbance by a solution.

It was hypothesized that lower temperatures would decrease the rate of DNA synthesis.

<u>Examples of stating a prediction based on the hypothesis:</u>
If higher solute concentration increases a solution's light absorbance, absorbance should increase as protein concentration increases.

If lower temperatures decrease DNA synthesis then DNA synthesis will be lowest under the coldest experimental temperatures.

Materials and Methods

The Materials and Methods section is a narrative describing what you did in your experiment and providing information about the materials that were used. Your goal is to give the reader enough information about your procedure and materials so they could replicate your experiment. The information is presented in a narration rather than a series of individual steps (as written in your lab handouts). The narration includes only those details essential to repeating the experiment and avoids describing routine procedures or materials that should be obvious to the reader. This section is always written in passive voice and past tense. Passive voice emphasizes the process rather than the person performing it. Ask your instructor for examples of good Materials and Methods sections.

Suggestions for writing a good Materials and Methods section:

1. Avoid making lists. Describe what you did in full, but concise, sentences.
2. Do not tell the reader what to do, tell them what you did.
3. Use passive voice and past tense.
4. Avoid including routine procedures or materials that not essential to conducting the experiment.

How many mistakes can you identify in this poorly written example?

First, we turned on the spectrophotometer and let it warm up for 20 minutes. Next, we set the wavelength to 595 nm and made sure the filter was set in the right range. Before putting anything in the chamber, we calibrated the spectrophotometer to 0% transmittance. Next, we put a cuvette with distilled water in it (the blank) into the chamber (after we wiped the cuvette with a *Kimwipe*®) and calibrated the spectrophotometer to 100% transmittance. Next, we made sure the mode was set to read absorbance. Then we took four cuvettes, each with a different concentration of BSA in it and measured its absorbance. After we had that data, we made a graph plotting absorbance vs. BSA concentration and drew a line of best fit. Next, we measured three more BSA solutions and used the standard curve to estimate their concentration.

Examples of appropriate Materials and Methods sections:

A Bradford protein assay was used to measure the absorbance of four Bovine Serum Albumin (BSA) solutions. Using a spectrophotometer (Spec 20+) the absorbance (595 nm) of solutions with BSA concentrations of 0.1, 0.3, 0.5 and 0.7 mg/mL were measured and the data used to construct a standard curve. The absorbance of three solutions with unknown BSA concentrations was measured and the standard curve used to estimate their BSA concentration.

Results

The Results section is where you report your data in writing and by using tables and/or figures (graphs). The written text summarizes the data so the reader has the general idea of your results prior to looking at the figures. A reference to a table or graph is done immediately following its description (Table 1) or (Figure 1) and then the table (or figure) is shown. Tables and graphs present summary information (not raw data) and follow a standard format. While you may be tempted to do so, you will save your interpretations and comments on the data for the Discussion section.

Suggestions for writing a good results section:

1. *Summarize* the data contained in tables and figures rather than writing all your data out in written form.
2. Include a reference (Figure 1) or (Table 1) to the visual presenting the data described.
3. Make your figures and tables first and then use them as a guide for writing the text.
4. Avoid repeating information that is in the Materials and Methods section
5. Save interpretation of the data for the discussion section.
6. Check to make sure tables or figures are formatted and captioned correctly.

Tables

1. Categories are arranged vertically in a logical order (increasing or decreasing value, alphabetical, etc.)
2. Columns are not separated by vertical lines and horizontal lines are used to separate title from column headings and column headings from data
3. Titles are placed **above** the table. Titles are generally not complete sentences and the only the first word and any proper nouns are capitalized.

Figures

1. The title is placed below the figure (graph) and only the first word of the caption and any proper nouns are capitalized.
2. The following formatting changes must be made when using Excel:
3. Remove **all** borders and gridlines
4. All lines/symbols should be in black (or different dash styles/symbol shapes).
5. Graph background must be white.

Example 1:

The average heart rate was higher immediately after exercise compared to resting heart rate for both age groups (Table 1). Recovery time was similar for both age groups (Table 1).

Table 1 Effect of age on cardiovascular fitness as measured by heart rate and recovery time

Age (years)	Average resting heartrate (bpm)	Average heartrate immediately after exercise (bpm)	Average recovery time (min)
20 and younger	73	113	3.8
Older than 20	74	122	4.0

Example 2:
Results show that heart rate was increased following exercise for all groups tested (Figure 1).

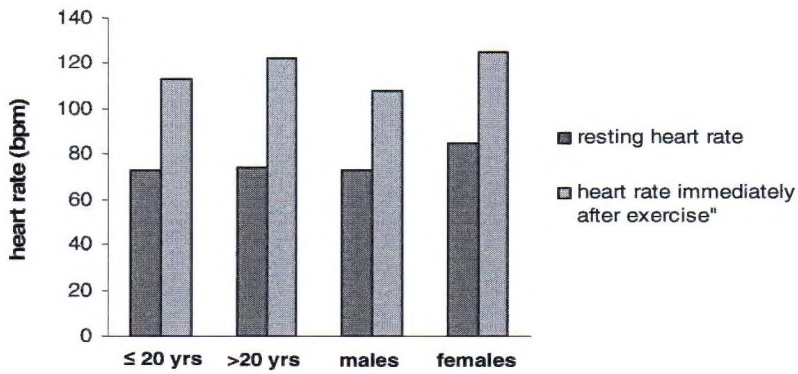

Figure 1 Heart rate as a measure of cardiovascular fitness.

Example 3:
The digestion of starch was fastest when amylase concentration was 0.5% and slowest at 0.1% (Figure 1). Concentrations of amylase 0.3% and lower demonstrated a steady decline in activity over 20 minutes compared to 0.5% amylase which digested the starch very rapidly during the first 10 minutes before slowing down (Figure 1).

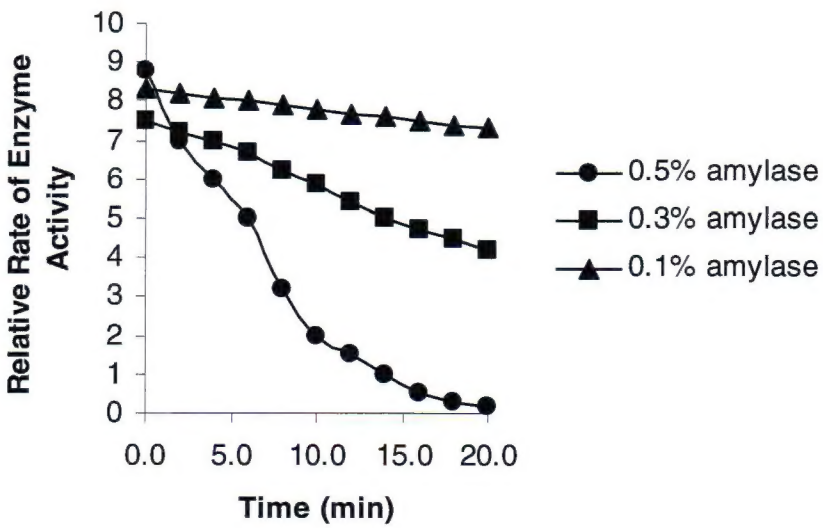

Figure 1 Effect of enzyme concentration on starch digestion.

Discussion

The Discussion section is where you interpret your data, draw conclusions, and discuss your experimental results in connection with the results from other scientists. As with the introduction, you are required to incorporate (and cite) relevant information from studies reported in primary journals and appropriate secondary sources. The Discussion section is the forum for you to *discuss* results with the reader. Following are some key points generally included in writing your discussion.

1. Emphasize your key findings and draw general conclusions.
2. If you started with a hypothesis, state whether it was supported by your results. If your hypothesis was not supported, provide a possible explanation.
3. Compare your results and interpretations with the work of other scientists or with current textbook information.
4. Provide an explanation of any unexpected results or problems you encountered during your experiment. If appropriate, discuss any problems or limitations to the procedure or technique of your experimental method.
5. Describe future experiments suggested by your results.
6. Speculate on the broad meaning of your results to the field of biology.

References or Works Cited

Although you conduct and analyze your experiment in collaboration with other students, your report must be written independently. Representing another person's ideas or expressions as your own constitutes plagiarism and is a serious offense. A Works Cited section provides information about each work you referenced in your paper (most of which, if not all, will be from your Introduction and Discussion sections). There are several acceptable ways to cite references in scientific papers; however, for consistency you should use the following formats.

Journal article with one or two authors:

Thomas, C. and Marshall, E. "Arthropod abundance and diversity in differently vegetated margins of arable fields." *Agriculture, Ecosystems and Environment,* 1999, vol 72, pp. 131-144.

Journal article more than two authors:

Nedorostova, L., Kloucek, P., Kokoska, L., Stolcova, M., and Pulkrabek, J. "Antibacterial properties of selected essential oils in vapour phase against food born bacteria." *Food Control,* 2009, vol 20, pp. 157-160.

Journal article accessed through the internet:

Young, H.S., Dirzo, R., Helgen, K.M., McCauley, D.J., Billeter, S.A., Kosoy, M.Y., Osikowicz, L.M., Salkeld, D.J., Young, T.P., and Dittmar, K. "Declines in large wildlife increase landscape-level prevalence of rodent-borne disease in Africa." *Proceedings of the National Academy of Sciences*, 2014, vol 111, pp. 7036-7041.
<http://www.pnas.org/content/111/19/7036.long> Accessed Jun 2, 2014.

Book:
Krogh, D. *Biology, 4th ed.* San Francisco: Pearson/Benjamin Cummings, c 2009.

5. Publication accessed via the internet:
U.S. Fish and Wildlife Service, 2009, Summer. "Salmon Research and Climate Change." <http://www.fws.gov/endangered/bulletin/2009/bulletin_summer2009-all.pdf.> Accessed Oct. 5, 2009.

The following format would be used to cite the above references in your Introduction and/or Discussion sections.
(Thomas and Marshall, 1999)
(Nedorostova et. al., 2009)
(Young, 2014)
(Krogh, 2009)
(U.S. Fish and Wildlife, 2009)

References:
Morgan, J. and Carter, E. "Scientific Writing and Communication," in Investigating Biology Lab Manual, 5th ed. San Francisco: Pearson/Benjamin Cummings, c 2005, pp. 763-772.
Steingraber S, Goldberg D, Jolls C. Guidelines for Writing Scientific Papers. <http://www.bms.bc.ca/resources/library/pdf/GuidelinesScientificPapers.pdf.> Accessed 9/24/09.
UWL Biology Guidelines for Scientific Writing, <http://www.uwlax.edu/wimp/dept/samples/bguidelines.doc.> Accessed 9/24/09.